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Zeiler

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[54] **APPARATUS FOR DISPERSING AND DIRECTING DYE ONTO A SUBSTRATE**

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[73] Assignee: **Milliken Research Corporation**, Spartanburg, S.C.

[21] Appl. No.: **898,232**

[22] Filed: **Jun. 12, 1992**

Related U.S. Application Data

[63] Continuation of Ser. No. 539,776, Jun. 18, 1990, abandoned.

[51] **Int. Cl.**[5] **B05B 17/04**

[52] **U.S. Cl.** ..... **239/295**; 239/124; 239/461; 137/825; 68/205 R; 118/326

[58] **Field of Search** ..... 68/205 R; 137/825; 118/325, 326, 679, 698; 239/99, 124, 290, 295, 461, 543, 544, 554, 555, 602, 434, 418

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Assistant Examiner—Christopher G. Trainor
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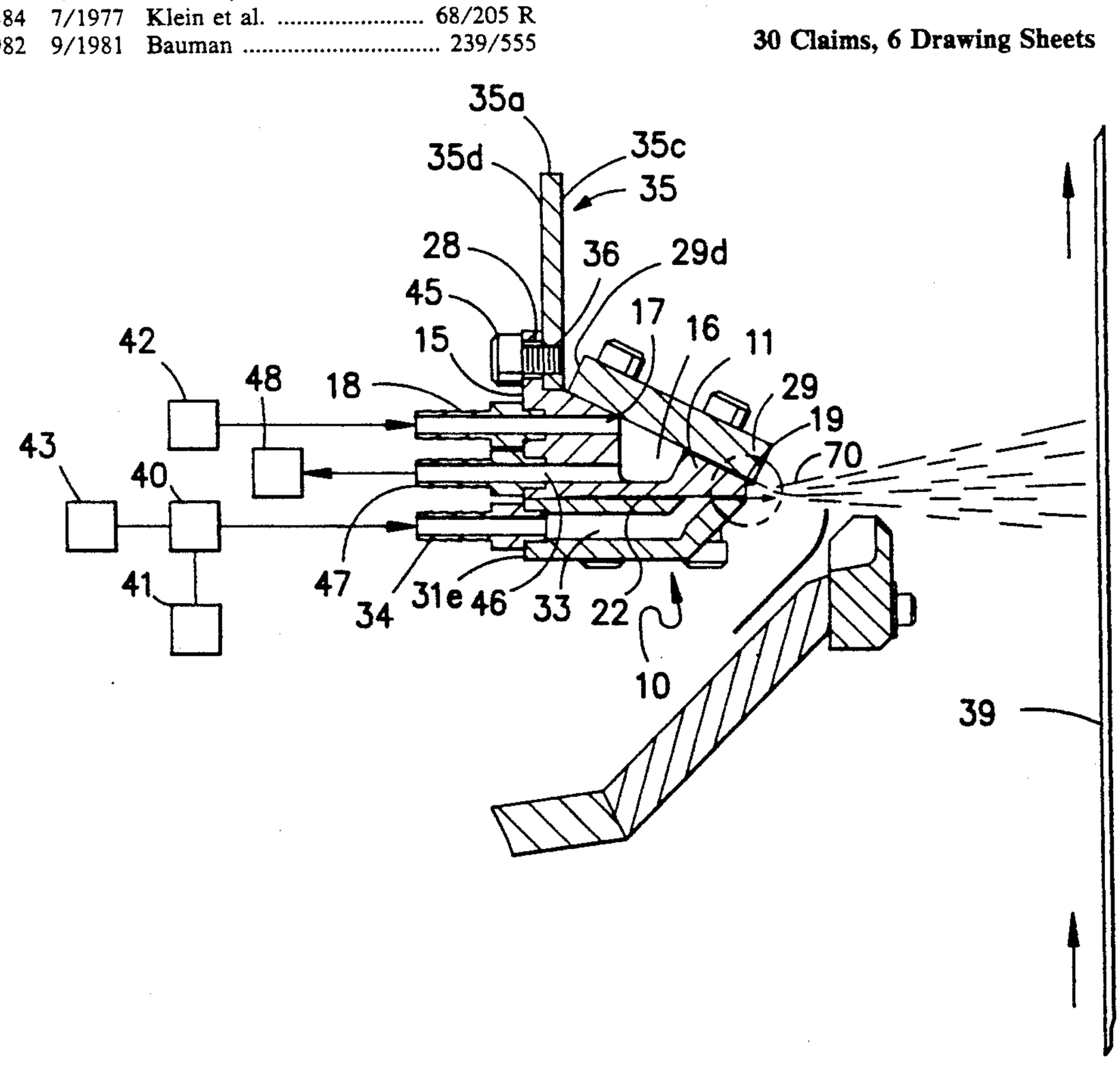
[57] **ABSTRACT**

An improved apparatus is disclosed for spraying a liquid marking material onto the surface of a substrate by dividing a stream of the marking material into droplets by an impinging stream of pressurized control fluid directed at the surface to be sprayed. The apparatus comprises a module forming a plurality of first conduits for delivery of the stream of marking material and a plurality of second conduits for delivery of the impinging stream of control fluid. In one embodiment, the module comprises a module body having a plurality of first grooves and a plurality of second grooves and means for enclosing such grooves to form the first and second conduits, respectively. Methods of producing substrates having a sprayed pattern are also disclosed which employ such apparatus.

30 Claims, 6 Drawing Sheets



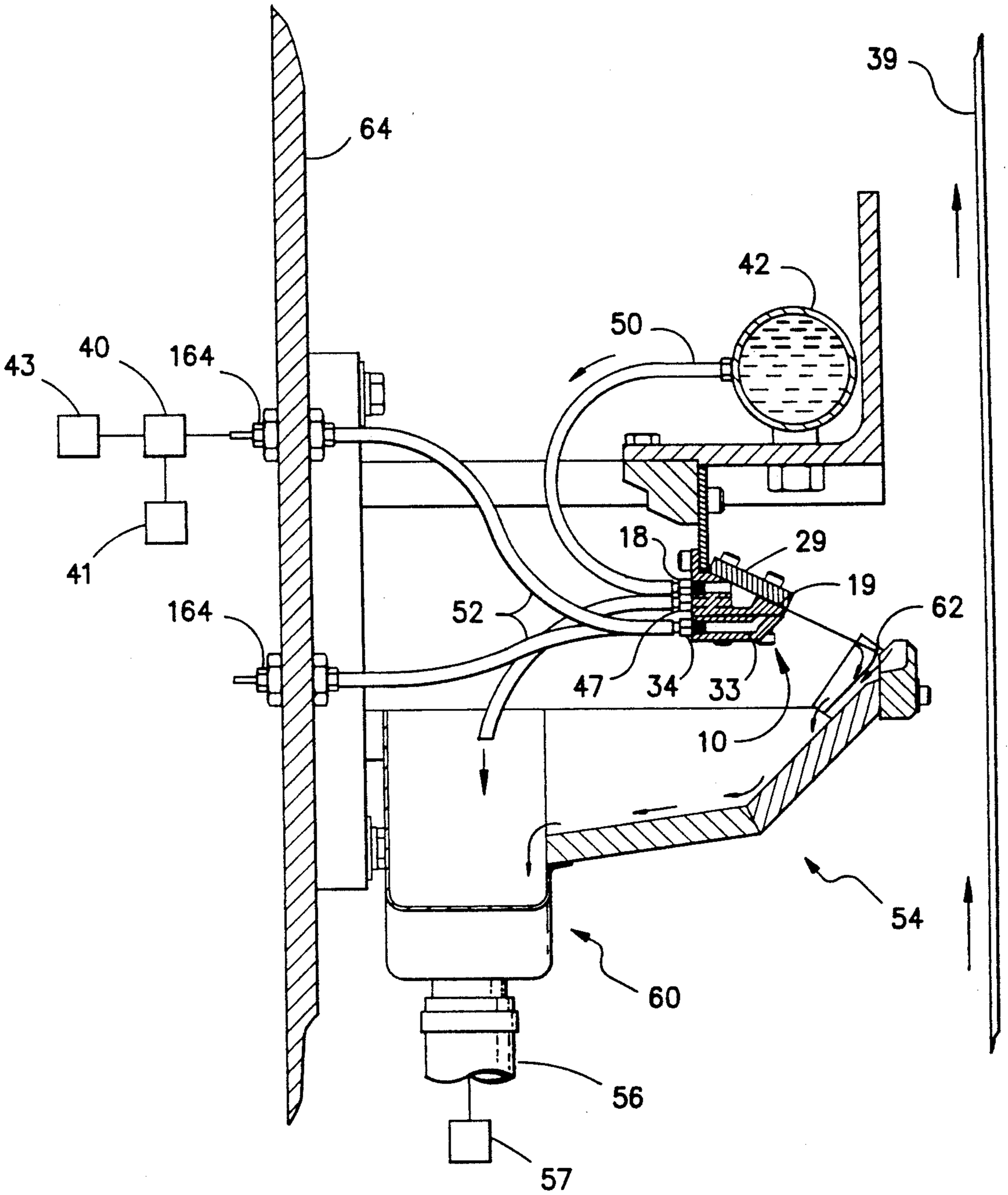


FIG. —1—

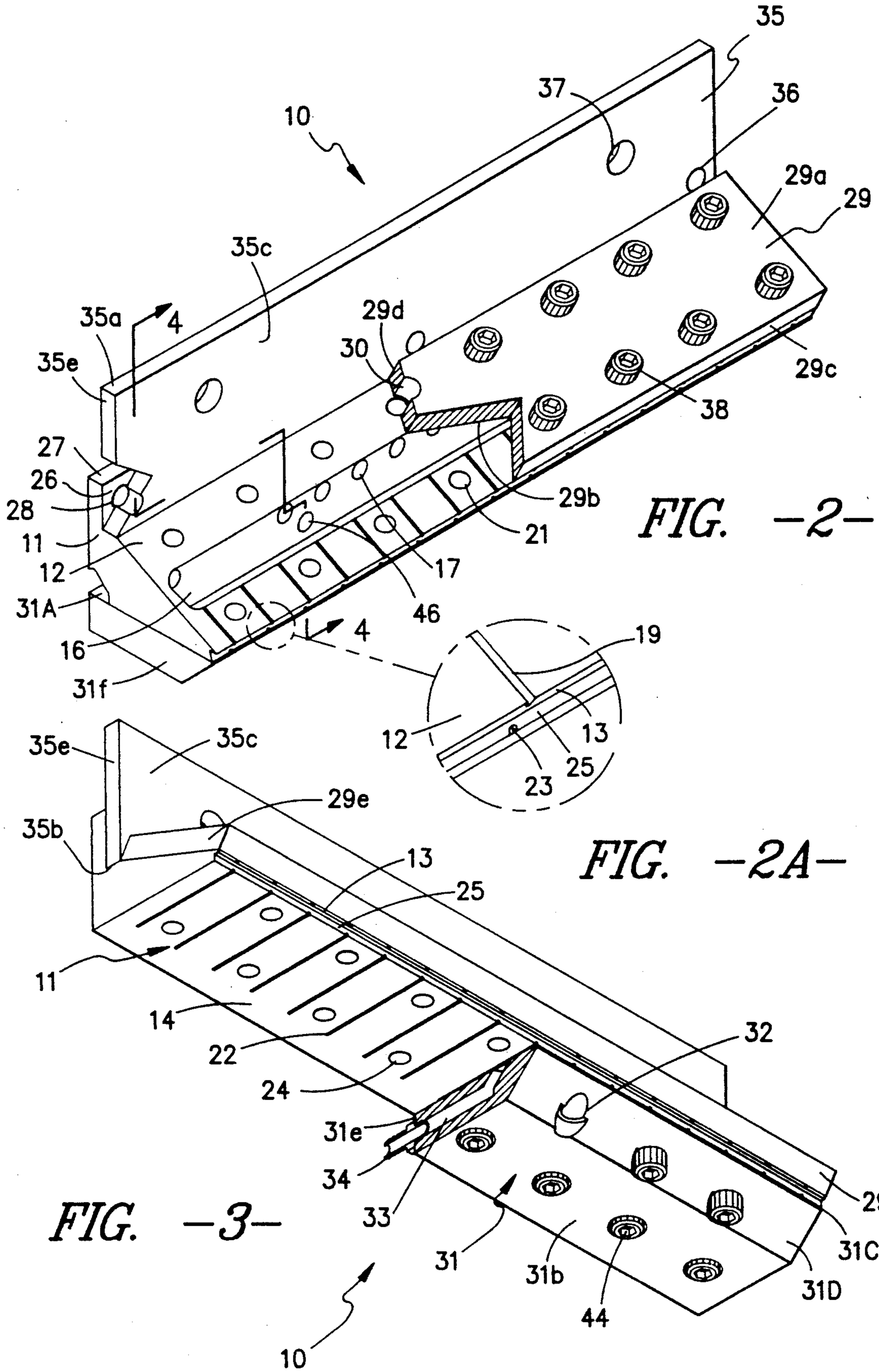
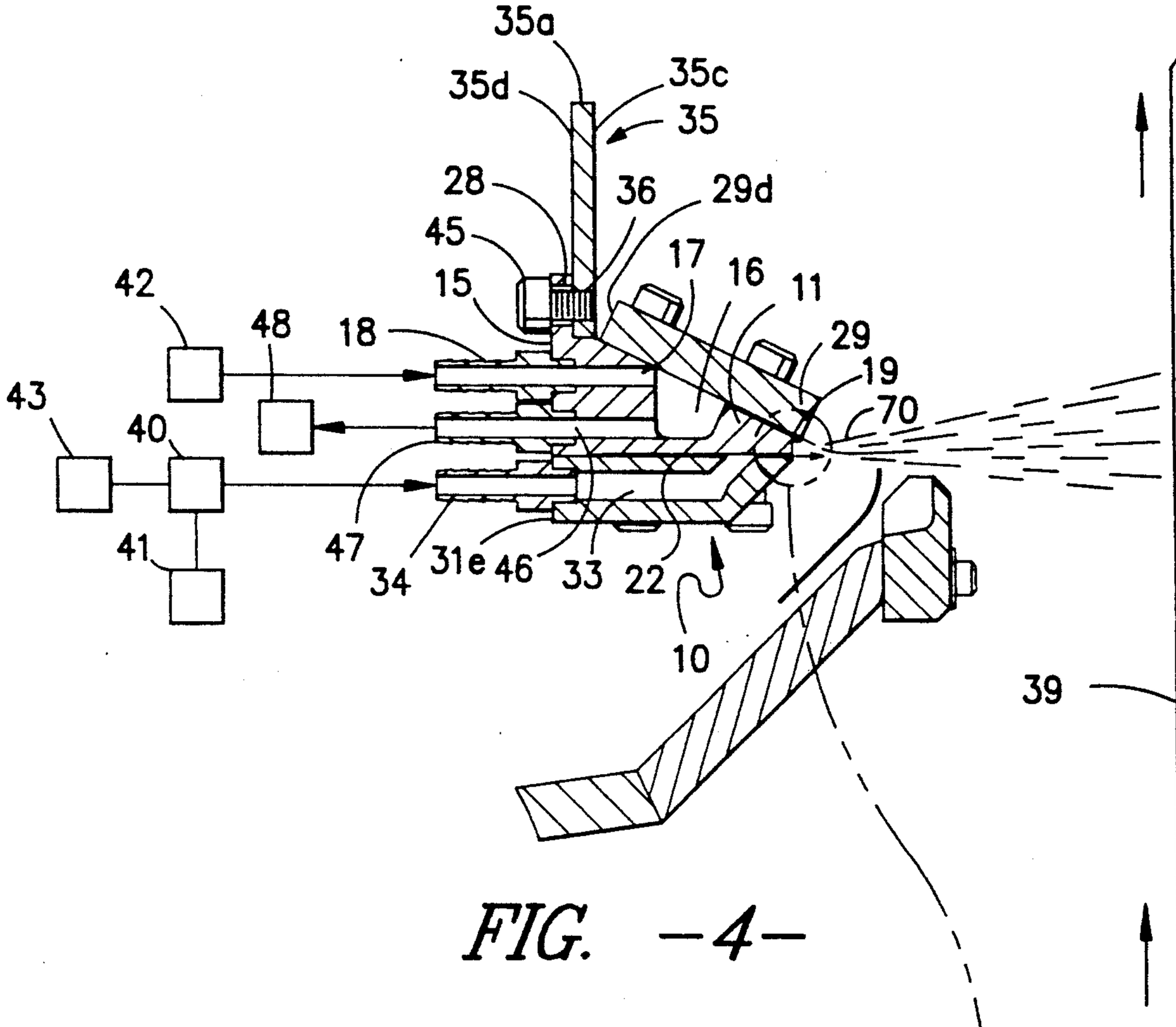


FIG. —2—

FIG. —2A—

FIG. —3—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35d
35c
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28
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29d
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16
11
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43
70
40
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34
31e
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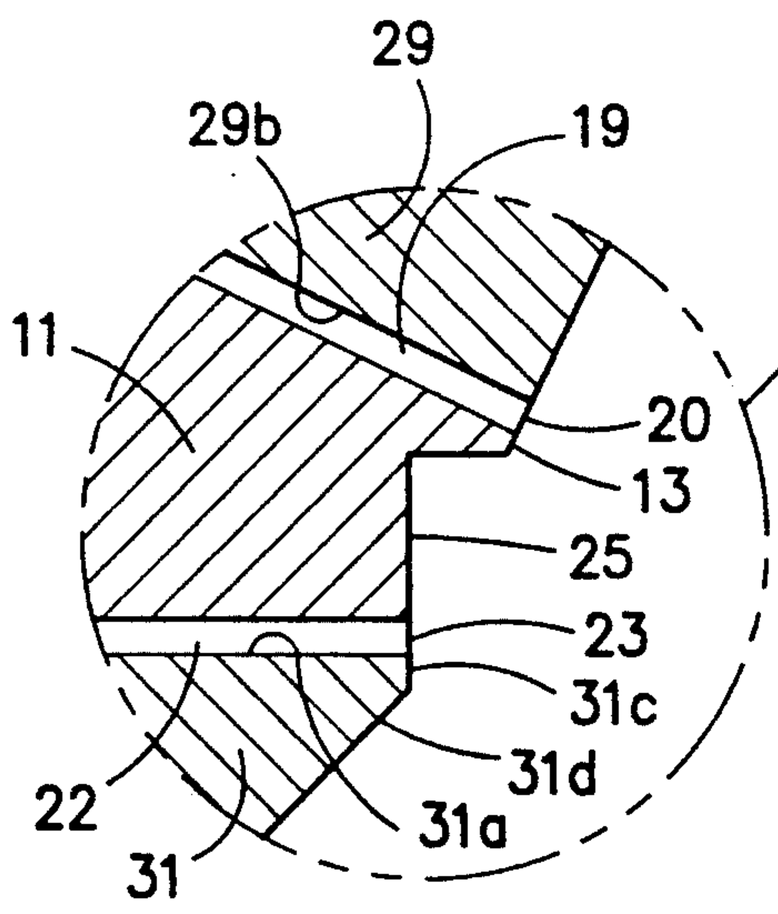
39

FIG. —4—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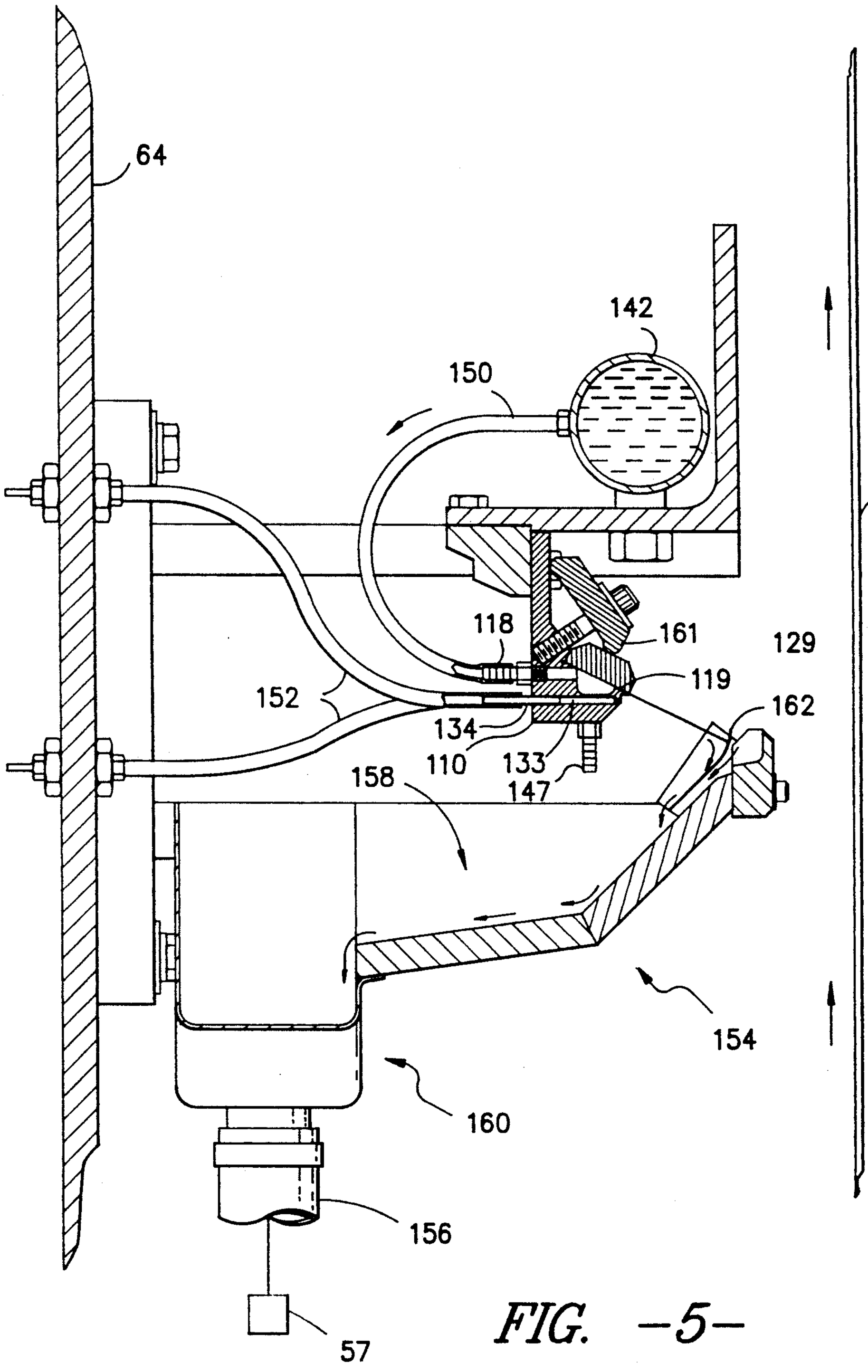
29b
19
11
20
13
25
23
31c
31d
22
31a
31

FIG. —4A—


64
142
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162
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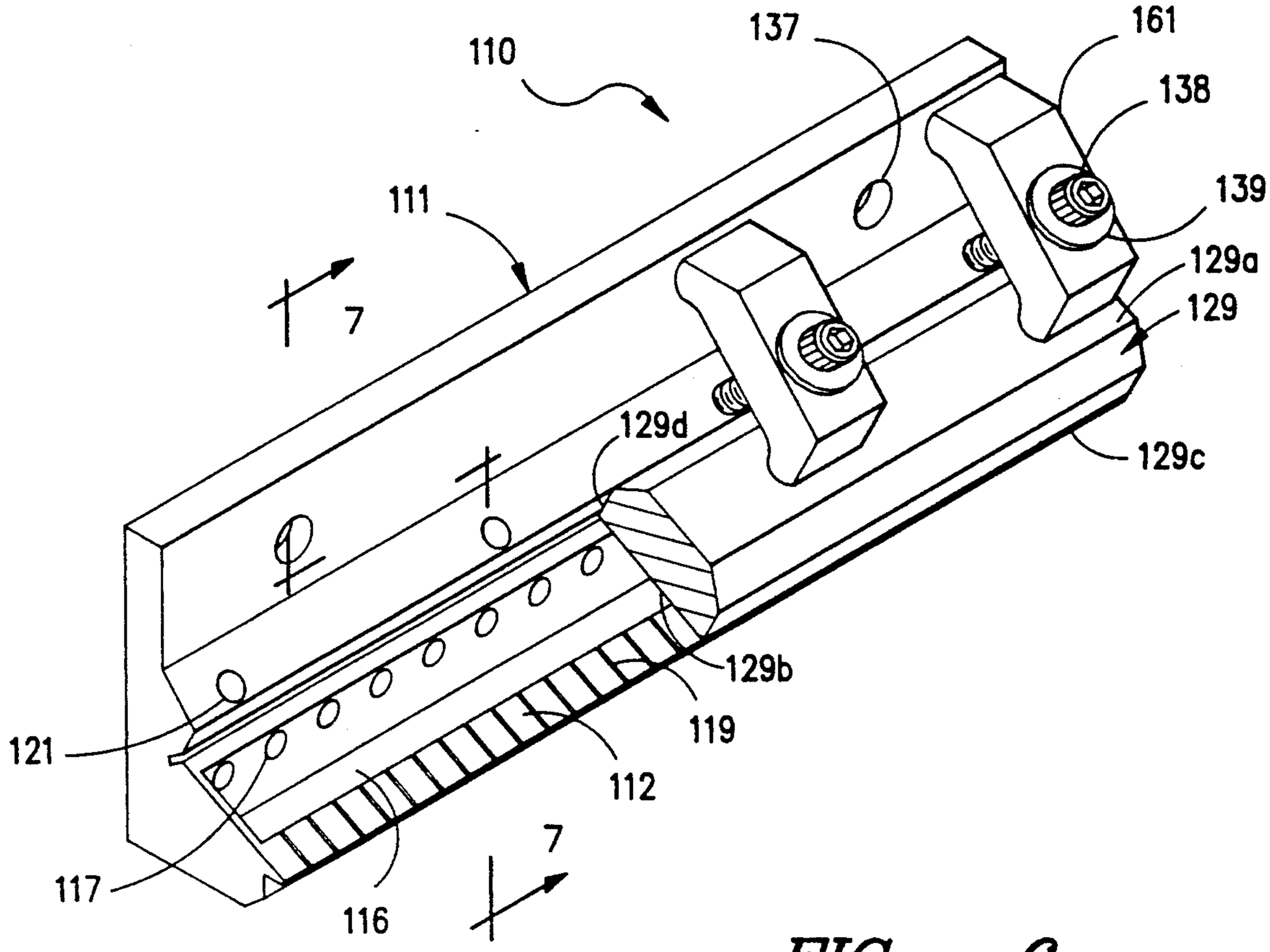
FIG. –5–


110
137
161
138
139
129a
129
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7
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129d
129c
129b
119
121
112
117
116
7

FIG. -6-

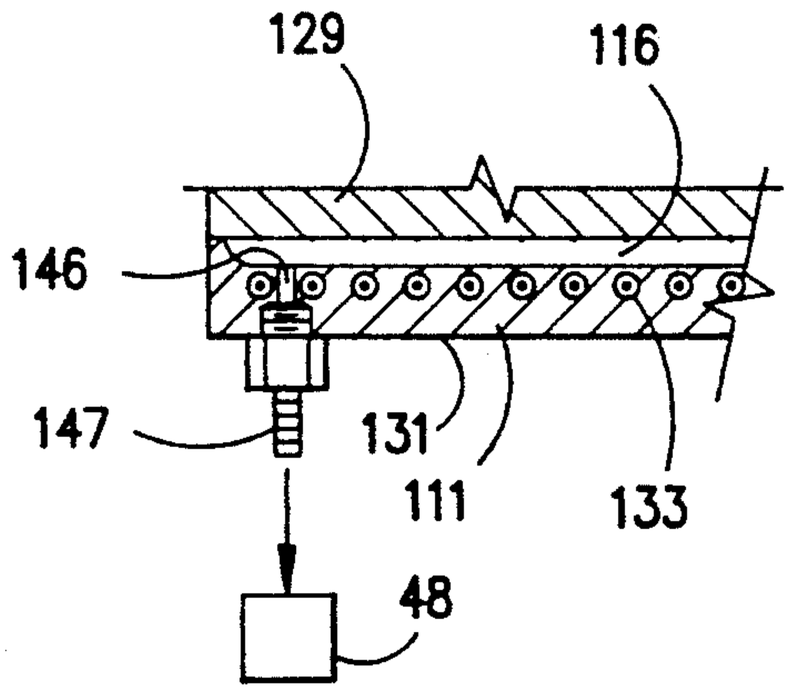
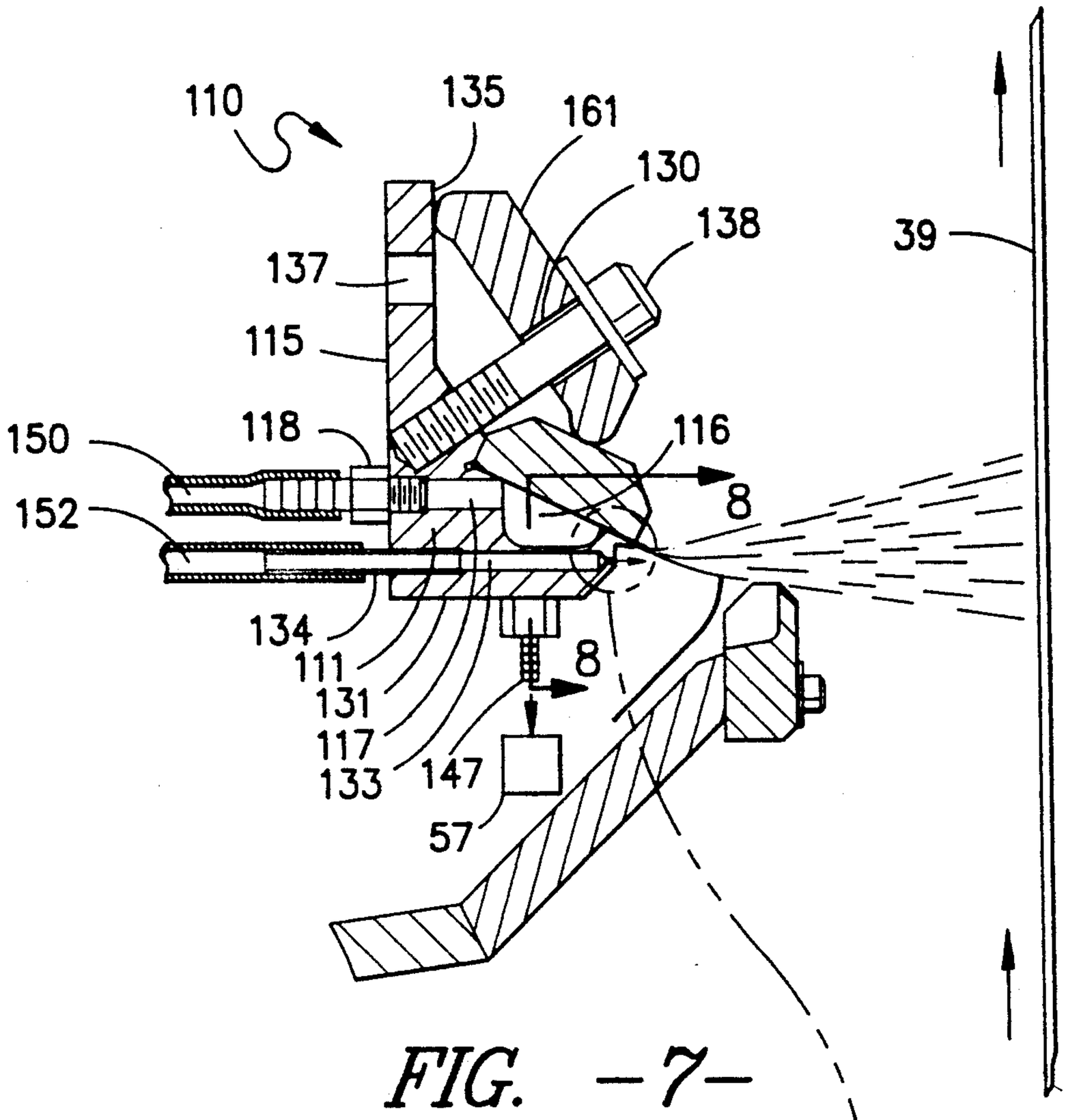

129
116
146
147
131
111
133
48

FIG. -8-


110
135
161
130
138
137
115
118
150
152
116
8
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111
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117
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147
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8
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FIG. —7—

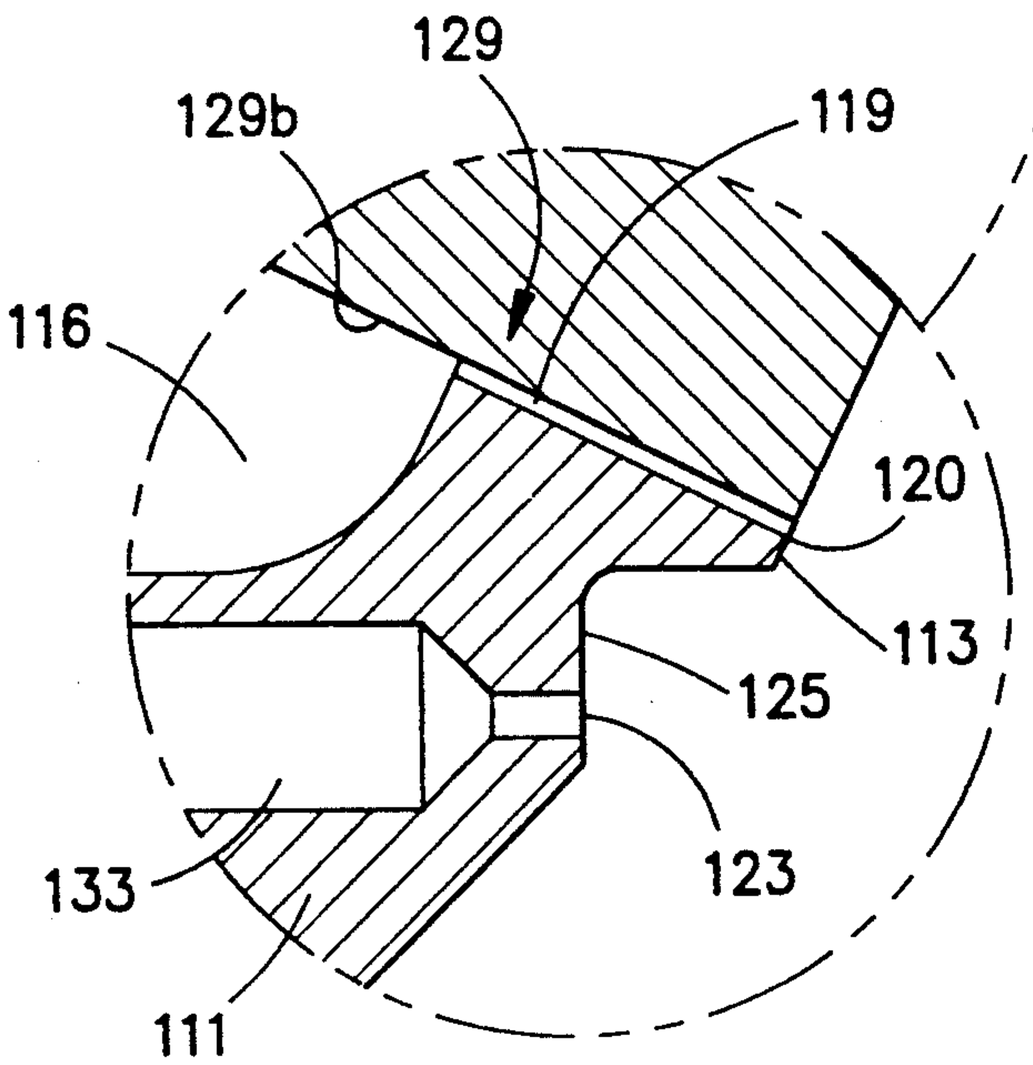
129
129b
119
116
120
113
125
123
133
111

FIG. —7A—

APPARATUS FOR DISPERSING AND DIRECTING DYE ONTO A SUBSTRATE

This application is a continuation of Ser. No. 07/539,776, filed Jun. 18, 1990, now abandoned.

FIELD OF THE INVENTION

The present invention is directed to apparatus for impressing marking materials (e.g., dyes, inks, paints, coatings) onto substrates (e.g., fabric) and, more particularly, to a mechanism for producing a plurality of aligned streams of atomized droplets to produce a dye pattern on a substrate.

BACKGROUND OF THE INVENTION

It is known to apply liquid dyes to moving substrates, particularly textile materials, from a plurality of streams which are directed onto such materials and selectively controlled to produce a pattern thereon. It is also known, in connection with such methods and apparatus, to use a control fluid, commonly air, as the means by which flow of liquid dye is controlled. While various techniques for control have been used, the control fluid methods commonly employ one of the following approaches.

In a first approach (see e.g., U.S. Pat. Nos. 3.985,006, 3,969,779 and 4,095,444), a stream of marking material is directed at the desired substrate and a transverse stream of a control fluid is used to divert the marking material stream into a barrier or the like, in response to externally supplied dyeing pattern information.

In a second approach (see e.g., U.S. Pat. Nos. 3,443,878 and 3,570,275), a curtain of marking material is directed in closely spaced, parallel relation to the desired substrate, and one or more streams of a control fluid are directed through the curtain in the direction of the substrate, thereby causing displacement of marking material from the curtain onto the substrate.

In a third approach (see e.g., U.S. Pat. No. 4,501,038), a stream of a control fluid such as air is directed into a mixing chamber in which a quantity of marking material is introduced in accordance with pattern information. The chamber may be positioned in close proximity to the desired substrate, and may be configured so that, for example, air enters the chamber from the top, intersects a flow of marking material entering the chamber from the side, and causes a spray of air and marking material to exit from the confines of the chamber, via a conduit extending from the bottom of the chamber, onto the desired substrate.

Although these apparatus have shown limited utility for the production of products with fairly regular dyeing patterns, they have proven inadequate to produce more "complex" patterned products of two basic categories. The first may be called a "diffuse pattern" product, in which the desired substrate has been marked or dyed in a pattern which exhibits soft, diffused color boundaries and perhaps exhibits color areas which overlap and blend almost imperceptibly from one to another, and which product may exhibit literally dozens or hundreds of different colors, shades, or hues over the pattern area. The second category may be called a "random pattern" product, in which the distribution of color within areas on the substrate has a random or pseudo random appearance. The color may be in the form of extremely small flecks or specks, or may be in the form of larger areas having irregular, random appearing borders. Some products exhibit characteristics which are a combination of these two categories, wherein, for example, irregularly shaped patches of color exhibit diffused boundaries and contain a multitude of varying shades or hues, and which may contain randomly distributed and/or overlapping specks of color in localized areas of the substrate.

Coassigned U.S. Pat. No. 4,923,743, entitled Apparatus and Method for Spraying Moving Substrates, discloses a unique apparatus that will produce such "complex" patterned products. Therein several arrays of closely spaced streams of marking material are normally directed into corresponding collection surfaces or receptacles. Each stream in a given array has associated with it a source of pressurized air or other control fluid which, on command, forms and directs an atomizing control fluid stream into contact with the marking material whereby the stream of marking material is transformed into a mist of variously sized diverging droplets which are propelled in the direction of the substrate to be marked. By interrupting the streams of atomizing fluid in oscillatory fashion, uniform reproduction of various solid color or multi-hued patterns is possible. By employing such controlled pulsations, the marking material sources, directing fluid sources, substrate, droplet size distribution and the degree of droplet dispersion can be carefully controlled, yielding intricate patterns possessing great subtlety, delicacy, and variety which may be produced with a high degree of reproducibility. By providing for the nonsimultaneous actuation of adjacent atomizing fluid streams along a given array, a wide variety of side to side or fill direction patterns may be produced.

In prior art apparatus, the conduits and orifices for delivery of the marking material have been fashioned separately from the conduits and orifices for delivery of the air (control fluid) stream. The separate components were then assembled in the desired configuration by mounting them in a holder along with other pairs of separate components to form an array of marking material/control fluid orifice combinations. For the machine to operate optimally, each orifice combination in the array must deliver exactly the same amount of marking material onto the substrate as its neighbor over the entire width of the substrate. Due to manufacturing tolerances in the conduits, orifices and the holder, the resulting tolerance build up of the components over the entire array was large enough to effect a variation in the geometry of the assembled components. This variation in geometry adversely affected the flow rate of the marking material and control fluid, the directivity of the marking fluid and control fluid, and the amount of aspiration induced pressure drop seen across marking material orifices. This in turn could produce a variation in marking material flow onto the substrate target area, creating streaks on the substrate.

The individual dye nozzles can be retracted from the air stream to eliminate aspiration, and the various components are or can be arranged for manual alignment. However, such an arrangement has proved to be labor intensive because of the number of component combinations involved (sometimes as many as 573 or 2000 combinations per machine) and the trial and error nature of the adjustments. Such an alignment procedure is not efficient or economical in the production environment. Additionally, because of the long length of the marking material conduit and because the conduit had a single exit orifice, a solid contaminant, once in the con-

duit would clog the orifice and would be difficult to remove.

The invention described herein provides a mechanism whereby the geometry of the air and dye conduits and orifices is maintained to minimize or eliminate variation in dye flow rate and directivity to the substrate without the need to employ complex and inefficient alignment procedures. With this mechanism aspiration of dye is permanently eliminated from the process and whereby solid contaminants can be more easily removed from the marking material conduit. Other features are set out in the Summary of Invention below.

SUMMARY OF THE INVENTION

In accordance with the present invention, an apparatus is disclosed for spraying a liquid marking material onto the surface of a substrate. For this purpose a stream of the marking material is divided into droplets by an impinging stream of pressurized control fluid directed at the surface to be sprayed. The apparatus comprises a module forming a plurality of conduits for delivery of the stream of marking material and another plurality of conduits for delivery of the impinging stream of control fluid. The conduits can be formed within a single piece module, from separate pieces, by covered and enclosed grooves, or it can be formed directly into the single piece by precision locating, sizing and orienting a hole, or by other means. In one embodiment, the module is a unitary structure or body having a plurality of enclosed grooves corresponding to the conduits mentioned above. The module can be formed from stainless steel or other materials such as plastics, brass, or any other corrosion resistent material. The material employed should be capable of being machined to form the grooves and other elements needed to facilitate delivery of the various fluids. Manufacture of the modules should not be limited to machining, as precision reaction injection molding should be able to provide precise and uniform marking material and control fluid conduits as well as highly accurate and uniform alignment between the conduits that make up the pairs.

The module also includes a trough or cavity for holding marking material for delivery. A supply system provides pressurized marking material to the trough, ultimately for delivery through the module for spraying.

The grooves can be enclosed by any covering which will form the necessary conduits for marking material and control fluid delivery. In one embodiment, the grooves are enclosed by respective upper and lower cover plates. Alternatively, both sets of grooves could be enclosed by a single structure. In some embodiments the cover plates also provide other features including channels for supplying marking material or control fluid to the respective conduits or the trough which is in communication with one end of one set of the enclosed conduits and a set of bypass conduits.

When assembled, the module contains delivery paths for marking material and control fluid. The marking material is delivered from its pressurized source to the trough which is in communication with one end of one set of the conduits. The other end of the enclosed conduits is exposed to the exterior of the module body in the form of an orifice for spraying the marking material. The trough is also in communication with one end of one set of bypass conduits. The other end of the bypass conduits is exposed to a recirculation system, these conduits allow marking material contaminants to bypass the enclosed conduits and exit the trough into a recirculation system where they are removed from the marking material through filtration. The control fluid is delivered from its pressurized source into the control fluid supply channel which is in communication with the other set of conduits. One end of each of these conduits is exposed to the exterior of the module body ending in an orifice for emitting the control fluid.

In other embodiments, the module can be constructed from a single piece of material without the need for additional covering or closing structure to form the necessary conduits. In such embodiments, the conduits are formed in the module during its manufacture by, for example, machining or casting or molding. Any module which contains a plurality of conduits which are permanently (i.e., unchanging without further manufacturing or processing of components) fixed in orientation with respect to each other is contemplated as within the scope of the present invention, regardless of its construction or means of manufacture.

The above is a brief description of certain problems with the prior art and some advantages of the invention. Other features will become apparent from the Detailed Description which follows.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a sectional view through a module comprising a first embodiment, utilizing separate module blocks for liquid dye and air.

FIG. **2** depicts the embodiment of FIG. **1** in a perspective view from above with a portion removed; FIG. **2A** shows a detail, as indicated.

FIG. **3** depicts the embodiment of FIG. **2** in a perspective view from the bottom with a portion removed;

FIG. **4** is a cross section of the embodiment of FIG. **2** taken along lines **4—4**; FIG. **4A** shows a detail, as indicated.

FIG. **5** is a sectional view through a module comprising a second embodiment, utilizing a single module block for both dye and air.

FIG. **6** depicts the embodiment of FIG. **5** in a perspective view in partial section, as viewed from above.

FIG. **7** is a cross-section of the embodiment of FIG. **5** taken along lines **7—7** of FIG. **6**;

FIG. *7a* shows a detail, as indicated.

FIG. **8** is a cross-section of the embodiment of FIG. **5** taken along lines **8—8** of FIG. **7**.

DETAILED DESCRIPTION

The embodiments depicted and described below in connection with FIGS. **1–8** use dye as the marking material and air as the control fluid. Although certain components are referred to with respect to air or dye, it is understood that those same components would be used for other control fluids and marking materials, respectively.

Before discussing the details of each embodiment, it may be helpful to discuss briefly the overall system in which various elements appear. Referring to FIG. **1** (which depicts a first embodiment), there is shown module **10** connected to a dye supply manifold **42** via external dye conduit **50**. Air lines **52** at one end are connected to module **10** through fittings **34**, which in turn are in fluid communication with air holes or passages **33** formed in module **10**. The other ends of air lines **52** are connected to fittings **164** in front wall **64** which, via additional suitable conduits, are ultimately connected to

control valve **40**. Control valve **40**, by way of controller **41**, controls the air delivered from air source **43**.

A diverting lip or blade **62** is located between module **10** and moving fabric **39**, in the path defined by dye grooves **19** (see FIGS. **2** and **2A**). The marking material delivered under pressure from manifold **42** is directed as a dye jet toward diverting lip or blade **62**. A catch trough **54** in communication with dye basin **60** is arranged in communication with the blade **62** to receive the liquid dye diverted by the blade **62** thereto. The dye collected in dye basin **60** is diverted through pipe outlet **56** back to reservoir **57** for reuse.

The exit orifices of air passages **33** are arranged to provide jets of air under pressure that intersect the dye streams and divert a portion thereof to the moving substrate **39**. Controller **41** controls the delivery of air, via individual valves **40**, through lines **52** according to a preselected pattern. Bursts of air according to the pattern cause droplets of dye material to impact on the substrate **39** and form the desired pattern. Other details of the apparatus are discussed below.

As can be seen in FIGS. **2** through **4A**, the central component of module **10** is body **11**, a wedge shaped block of stainless steel having an upper planar surface **12**, front surfaces **13** and **25**, a lower planar surface **14**, a back surface **15**, a mounting surface **26** and a top surface **27**. Upper planar surface **12** forms an angle of 90° with front surface **13** and an angle of 26° with lower planar surface **14**, lower planar surface **14** forms an angle of 90° with front surface **25** (see FIGS. **2**, **2A** and **3**). A trough **16**, extending generally longitudinally almost the entire length of module **10**, is formed in body **11** having a depth sufficient to hold and supply dye for spraying. Trough **16** opens into the upper planar surface **12** of body **11**, with the open portion extending the entire length and width of the trough.

Dye supply conduits **17** (diameter 0.159 inches) extend from the back surface **15** of body **11** into trough **16** and are fitted with dye supply fittings **18** for connection to pressurized dye manifold **42**. As can best be seen in FIGS. **2** and **2A**. upper planar surface **12** of body **11** has dye grooves **19** which extend from trough **16** to the dye orifices **20** on the front surface **13** of body **11**, forming a path for dye flow from trough **16** to the dye orifices **20**. Dye grooves **19** are longitudinally spaced along body **11** at intervals of about 0.400 inch, with each groove **19** having the same predetermined uniform cross-sectional area.

As shown in FIG. **4**, dye bypass conduits **46** (each having a diameter of 0.159 inch) extend from the trough **16** to the back surface **15** and tangent to the trough bottom, and are fitted with dye return fittings **47** for connection to a dye recirculation system **48**.

Looking at FIG. **2**, upper planar surface **12** of body **11** also contains threaded upper fastening holes **21** (diameter 0.164 inch) which are longitudinally spaced in two rows between alternate pairs of dye grooves **19**. As best shown in FIGS. **3**, **4** and **4A**, the lower planar surface **14** of body **11** has air grooves **22** which extend from a point within body **11** near back surface **15** to air orifices **23** in front surface **25**. Air grooves **22** are longitudinally spaced along body **11** at intervals of 0.400 inch, with each air groove **22** being paired with a corresponding dye groove **19**. Both grooves lie in the same plane. Each air groove **22** has a constant radius of curvature throughout its entire length of about 0.015 inches.

Lower planar surface **14** also contains threaded lower fastening holes **24** (diameter 0.164) which are arranged in two rows. The lower fastening holes **24** in the front row are spaced longitudinally along body **11** and between alternate pairs of air grooves **22**, with the first hole in the front row located between the second and third air grooves. The holes in the back row are similarly spaced, with the first hole in the back row located between the first and second air grooves.

Grooves **19** and **22** are machined on a Moore Jig Boring Machine that has guaranteed X and Y positional tolerances and squareness tolerances within 20 millionths of an inch. Two machining setups are required, one for dye grooves **19** and one for air grooves **22**.

As shown in FIGS. **2A** and **4A**, the planar front surface **13** has dye orifices **20**, and the front surface **25** has air orifices **23**, for delivery of the two respective fluids from the module body **11**. Air orifices **23** and dye orifices **20** are separated by approximately 0.10 inch.

As best seen in FIGS. **2**, **3**, and **4A**, upper cover plate **29** is a rectangular block of stainless steel having planar upper, lower, front, back and side surfaces **29***a*, **29***b*, **29***c*, **29***d* and **29***e*, respectively. Bolt clearance holes **30** (diameter 0.177 inch) extend through upper cover plate **29** from the upper surface **29***a* to the lower surface **29***b* and are spaced to align with upper fastening holes **21** when assembled with body **11**.

Lower cover plate **31** is a wedge shaped block of stainless steel having planar upper, lower, protruding front, receding front, back and side surfaces **31***a*, **31***b*, **31***c*, **31***d*, **31***e*, and **31***f*, respectively. Bolt clearance holes **32** (diameter 0.177 inch) extend through lower cover plate **31** from the upper surface **31***a* to the lower surface **31***b* and receding front surface **31***d*, and are spaced to align with lower fastening holes **24** when assembled with body **11**. Lower cover plate **31** contains air supply channels **33** which are fitted with air supply fittings **34** extending from the back surface **31***e* of the lower cover plate **31** to an opening on its upper surface **31***a*. Air supply channels **33** are spaced to align with each air groove **22** when assembled with body **11**.

Mounting plate **35** is a rectangular stainless steel block having planar upper lower, front, back and side surfaces **35***a*, **35***b*, **35***c*, **35***d* and **35***e*. Mounting holes **36** and **37** (having threaded diameter 0.250 inch and clearance diameter 0.281 inch, respectively) extend through mounting plate **35** from the front surface **35***c* to the back surface **35***d*. Mounting holes **36** are spaced to align with mounting clearance holes **28** when assembled with body **11**. Mounting clearance holes **37** are spaced to align with appropriately threaded holes associated with mounting fixtures on the apparatus in which the module **10** is used.

The module **10** is assembled by placing the lower surface **29***b* of upper cover plate **29** onto the upper planar surface **12** of body **11** such that upper fastening holes **21** align with bolt holes **30**, and such that front surface **29***c* of the upper cover plate is flush with the front surface **13**. Threaded bolts **38** are then placed through bolt holes **30** and into upper fastening holes **21**. Bolts **38** are tightened to produce a liquid tight seal between upper cover plate **29** and body **11**. Such seal may require use of soft metal plating or other suitable sealing techniques.

The upper surface **31***a* of lower cover plate **31** is placed onto the lower planar surface **14** of body **11** such that lower fastening holes **24** align with bolt holes **32** and air supply channels **33** align with air grooves **22**,

and such that the protruding front surface **31***c* is flush with front surface **25**. Threaded bolts **44** are then placed through bolt holes **32** (counterbored on surfaces **31***b* and **31***d*) and into lower fastening holes **24**. Bolts **44** are tightened to produce a seal between lower cover plate **31** and body **11**. Threaded air supply fittings **34** are inserted into the ends of air supply channels **33** on the back surface **31***e* of lower cover plate **31**. Threaded dye supply fittings **18** are inserted into the ends of dye supply conduits **17** on the back surface **15** of body **11**. Finally, mounting plate **35** is attached to body **11** such that fastening holes **36** align with bolt clearance holes **28**. Threaded bolts **45** are then inserted and tightened.

Once assembled, module **10** provides an array of dye conduits and air conduits for delivering dye and air through the module. The lower surface of upper cover plate **29** encloses dye grooves **19** to form covered dye conduits extending from trough **16** to dye orifice **20**. The upper surface **31***a* of lower cover plate **31** encloses air grooves **22** to form air conduits which are in communication with air supply channels **33** and which end in air orifices **23**.

The assembled module **10** is used to spray patterns on a substrate. The module **10** is attached through mounting holes **37** to a spraying machine, such as that disclosed in the previously referenced copending and coassigned U.S. patent application, that provides a pressurized dye source, a pressurized air source, a pressurized air source and means for selectively controlling the flow of air. The pressurized dye source, via manifold **42** and external dye conduit, is connected to dye supply fittings **18**. Dye can then flow in a continuous path from the dye source, into trough **16**, through the dye conduits formed by dye grooves **19** and out through dye orifices **20** and through the bypass conduits **46**. The pressurized air source is connected to air supply fittings **34**. When air flow is desired, air can flow in a continuous path from the air source **43**, via fittings **164**, air lines **52**, fittings **34**, air supply channels **33**, through the air conduits formed by air grooves **22**, and out through air orifices **23**.

The operation of a spraying apparatus employing a module of the present invention can be described by considering the operation of a single air conduit/dye conduit pair and with reference to FIG. **4**. A control valve **40** associated with the pressurized air source **43** prevents air from flowing to air supply fitting **34**. Dye is continuously supplied by pressurized dye source **42** to dye supply fitting **18** and flows out dye orifice **20**. The dye stream emanating from dye orifice **20** flows unimpeded into the surface of diverting lip or blade **62**, which collects the dye in catch trough **54** for disposal or recirculation to reservoir **57**.

When dye from the dye stream is to be applied to the substrate **39**, pulses of air generated by the opening and closing of the control valve **40** are supplied from the pressurized air source **43** to air supply fitting **34**. The air stream emanating from air orifice **23** impinges the dye stream, disrupting the regular flow of dye. As shown in the detail of FIG. **4A**, the dye orifice **20** and air orifice **23** are positioned such that the dye is contacted with air after it exits from the dye orifice **20**. As a result of the interaction of the higher pressure air stream (e.g. 25–40 p.s.i.g.) with the lower pressure dye stream (e.g., 2–4 p.s.i.g.) the dye stream is broken up into a spray of diverging droplets. The combined momentum of the two streams then carries the droplets to the surface of the substrate **39**. Because the dye exits the dye orifice **20** outside of the airstream envelope **70**, aspiration of dye from the dye supply conduit is eliminated, thereby eliminating the need to create uniform aspiration across the width of the module. To achieve the desired dying pattern, control valves for each conduit pair can be selectively opened and closed separately or in combinations according to pattern information supplied by controller **41**.

Two general dye flow streams exist in trough **16**. One stream (the supply stream) flows from the exit of each dye supply conduit **17** to the entrance of each dye conduit formed by dye groove **19**. The second flow stream (the bypass steam) flows from the exit of each dye supply conduit **17** to the entrance of each dye bypass conduit **46**. In the undesirable event that a solid contaminant lodges itself at the entrance to a dye conduit formed by dye groove **19**, thus restricting dye flow through that dye conduit, it can easily be pushed away from the dye conduit entrance and out of the supply stream and into the bypass stream by inserting a properly sized wire into the conduit from the orifice **20**. The solid contaminant would then exit the trough **16** by way of bypass conduit **46**, through the dye return fittings **47** and into the recirculation system **48** where it will be removed through filtration.

Additional information relating to the operation of such a spraying apparatus, including more detailed description of patterning and control functions, can be found in coassigned U.S. Pat. No. 4,923,743, which is incorporated by reference as if fully set forth herein.

Variations in dye delivery onto a substrate using the module of the present invention (as shown in FIGS. **1** through **4A**) and an array of separately manufactured and assembled components, as previously described and disclosed in coassigned U.S. Pat. No. 4,923,743, were compared. The maximum misalignment of the dye and air orifices in the latter apparatus was found to be 0.007 inch. The dye orifices in that apparatus were spaced 0.400 inch from each other and during dyeing the substrate was located **3.8** inches from the dye orifice. The relative angle between the air and dye streams is 26 degrees. Because of misdirectivity in the dye flow this angle varied from 22.5 to 29.5 degrees. This difference in relative angle varies the length of the dye stream in the diverging air stream. More specifically, the dye path length is 0.37 inches and 0.68 inches for the angles of 29.5 degrees and 22.5 degrees respectively. The length of dye stream in the air stream is atomized and deposited on the substrate. Because of the varying lengths of the dye stream in the air stream, a varying amount of dye is atomized and deposited on the substrate. This creates a visually obvious streak in the dye pattern.

In contrast, in a module of the present invention as described above, the relative angle between the air and dye stream is within the range of 25.5–26.5 degrees. The dye stream lengths in the air stream are 0.458 inches and 0.499 inches for angles of 25.5 degrees and 26.5 degrees, respectively. Additionally, the maximum misalignment of the dye and air orifices is 0.001 inch.

Due to the minimal amount of dye stream length variation and misalignment, the present invention provides means for producing very precise and uniform spray pattern applications. The module configuration of the present invention is also non-adjustable and tamper proof, thereby providing an added advantage for extended commercial production. The efficiency of dye deposition on the substrate is also improved by the configuration of the present invention, wherein the dye

orifice is not in the air stream. As shown in FIG. **4**, the dye orifice is positioned substantially outside the air stream envelope. This configuration maximizes the dye stream length that is positioned within the air stream envelope, and thereby atomized and carried by the air stream to the substrate.

The above describes one preferred embodiment of the invention. A second preferred embodiment is shown in FIGS. **5** through **8**. As many of the elements constituting this second embodiment are similar or identical to those discussed above, the entire apparatus will not be described. Rather, the focus will be on those elements which are different from or added to the apparatus described above.

Unlike the multi-piece system described in connection with FIGS. **1** through **4A**, the second embodiment is comprised of a single piece body **111** which does not require the additional lower plate **31**. Rather, the single piece body **111** has air passages **133** bored therethrough as can be more clearly shown in FIG. **7**. Air supply channels **133** are connected to air orifices **123** at one end and air fittings **134** at the other end, for connection to air hose or line **152**, asshown in FIG. **5**.

With regard to the dye delivery system, a dye channel or trough **116**, similar to trough **16** in the first embodiment, is formed in body **111** as shown. Trough **116** communicates with a number of dye conduits **117**, as can be seen in FIG. **6**, along the rear wall of trough **116**. Dye conduits **117** are in fluid communication with dye fittings **118** that communicate with the rear wall **115** of the module **110**. Threaded fittings **118** provides a means for connecting the dye conduits **117** to external dye conduits **150**, which in turn are connected to the dye supply manifold **142** as shown in FIG. **5**.

Upper planar surface **112** of body **111** has a number of dye grooves **119** which extend from trough **116** to dye orifices **120** on the front surface **113** of body **111**, forming a path for dye flow through **116** to dye orifice **120**. Dye grooves **119** are longitudinally spaced along the body **111** at intervals of about 0.200 inch, with each groove having the same predetermined uniform cross-sectional area.

Unlike the earlier embodiment, however, the dye bypass conduit **146** extends from the trough **116** to the bottom surface **131** of body **111** and is fitted with dye return fittings **147** for connection to a dye recirculation system **48**.

Air orifices **123** are longitudinally spaced along body **111** at intervals of about 0.200 inch, with each air orifice **123** being paired with a corresponding dye groove **119** with both the groove **119** and the air orifice **123** lying in the same plane. Each air orifice **123** is drilled and reamed to a constant radius of curvature throughout its length of about 0.011 inches. Each air orifice **123** is in communication with air supply channel **133**. Fitting **134** joins air line **152** to bore **133** As can be seen in FIGS. **4***a* and *7a*, the planar front surfaces **113** and **125** of body **111** are arranged identically as shown with regard to the first embodiment with corresponding surfaces **13** and **25**.

The upper cover plate **129** is a block of stainless steel with its planar upper, lower, front, back and side surfaces **129***a*, **129***b*, **129***c*, **129***d* and **129***e*. Mounting surface **135** corresponds to surface **35***c* of the first embodiment. Unlike the first embodiment, rather than having bolt holes extend directly through the upper cover plate, a series of clamps **161** are arranged which interact with mounting surface **135**. The module **110** is assembled by placing lower surface **129***b* of upper cover plate **129** on planar surface **112** of body **111** such that the side surfaces **129***e* of the upper cover plate are flush with the side surfaces of body **111** and such that the front surface **129***c* of upper cover plate **129** is flush with front surface **113**. Threaded bolts **138** are then placed through the clearance holes **130** in the clamps **161** and are threaded into the upper fastening holes **121**. Bolts **138** are tightened to cause clamps **161** to produce a liquid tight seal between the upper cover plate **129** and upper surface **112** of body **111**.

The operation of this embodiment is similar to that described above with respect to the first embodiment except for the bypass conduit **146**, which in this embodiment has a path perpendicular to that of the inlet conduit **117** for the dye, as can be seen in FIGS. **5**, **7**, and **8**.

From the foregoing, it will be apparent to those skilled in the art that various modifications in the above described devices can be made without departing from the spirit and scope of the invention. Accordingly the invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Present embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed is:

1. An apparatus for spraying a liquid marking material onto the surface of a substrate utilizing a source of pressurized control fluid and a source of liquid marking material, said apparatus comprising:

(a) a block of rigid material having a plurality of first conduits for delivery of said marking material and a plurality of second conduits for delivery of said pressurized control fluid;

(b) each of said first conduits having an inlet and an outlet for said liquid marking material;

(c) each of said second conduits having an inlet and an outlet for said pressurized control fluid;

(d) said inlet of each of said first conduits arranged for connection to said source of marking material;

(e) said inlet of each of said second conduits arranged for connection to said source of control fluid;

(f) said outlets of said second conduits arranged adjacent to corresponding outlets of said first conduits and cooperating to effect division of a stream of said marking material exiting said outlets of said first conduits into droplets by an impinging stream of said pressurized control fluid exiting said outlets of said second conduits; and

(g) a means for nonaspiratively positioning said outlets of said first conduits outside said stream of said pressurized control fluid.

2. The apparatus according to claim **1** wherein said first and second conduits are formed at least in part from corresponding first and second grooves formed in said block.

3. The apparatus according to claim **2** wherein said conduits further comprise: first closure means for enclosing said first grooves to form said first conduits; and second closure means for enclosing said second grooves to form said second conduits.

4. The apparatus of claim **3** wherein said first closure means is a first plate abutting said module body such that said first grooves are enclosed.

5. The apparatus of claim 4 wherein said second closure means is a second plate abutting said module body such that said second grooves are enclosed.

6. The apparatus of claim 5 wherein said second plate of said second closure means comprises a surface for abutting said module body and a plurality of air supply channels extending through said plate with inlets for connection to pressurized air and outlets for connection to said inlets of said second grooves.

7. The apparatus according to claim 1 wherein at least one of said first and second conduits includes passages formed completely by the surfaces of said block and extending through said block.

8. The apparatus according to claim 1 wherein said second conduits include passages bored through said rigid material.

9. The apparatus according to claim 8 wherein said first conduits includes grooves formed in said block and said second conduits include passages through said block.

10. The apparatus according to claim 9 wherein said conduits further comprise: first closure means for enclosing said first grooves to form said first conduits.

11. The apparatus of claim 10 wherein said first closure means is a first plate abutting said module body such that said first grooves are enclosed.

12. An apparatus for spraying a liquid marking material onto the surface of a substrate by nonaspiratively dividing a stream of said marking material into droplets by an impinging stream of pressurized control fluid directed at said surface, said apparatus comprising:

a rigid module body having a plurality of first grooves, a plurality of second grooves, and a trough having a means for removing possible contaminants in said marking material;

an upper cover plate abutting said module body such that a surface of said upper plate encloses said first grooves so as to form a plurality of first conduits for delivery of said marking material, said first conduits having one end in communication with said trough and another end extending to the outside of said module body and forming a marking material orifice;

a lower cover plate abutting said module body such that a surface of said lower cover plate encloses said second grooves to form a plurality of second conduits for delivery of said impinging stream of said control fluid, said lower cover plate forming a control fluid supply channel, said second conduits being in communication with said control fluid supply channel and having one end extending to the outside of said module body and forming a control fluid orifice; and

a means for nonaspiratively positioning said marking material orifice outside said stream of pressurized control fluid.

13. The apparatus of claim 12 further comprising:

a first pressurized source for delivering said marking material into said trough such that said marking material continuously flows out of said trough, through said first conduits and out of said module body through said marking material orifices; and

a second pressurized source for delivering said control fluid into said control fluid supply channel such that said control fluid flows out of said control fluid supply channel, through said second conduits, and out of said module body through said control fluid orifices.

14. An apparatus for spraying a liquid marking material onto the surface of a substrate by dividing a stream of said marking material into droplets by an impinging stream of pressurized control fluid directed at said surface, said apparatus comprising a module forming a plurality of first conduits for delivery of said stream of said marking material through a marking material orifice and a plurality of second conduits for delivery of said impinging stream of said control fluid nonaspiratively, wherein each of said first conduits are permanently positioned with respect to any other neighboring first conduit and a means for nonaspiratively positioning said marking material orifice outside said stream of pressurized control fluid.

15. The apparatus of claim 14 wherein each of said first conduits is permanently positioned with respect to each other of said first conduits.

16. The apparatus of claim 15 wherein each of said first conduits is also permanently positioned with respect to each of said second conduits.

17. An apparatus for spraying a liquid marking material onto the surface of a substrate by nonaspiratively dividing a stream of said marking material into droplets by an impinging stream of pressurized control fluid directed at said surface, said apparatus comprising:

a module forming a plurality of first conduits for delivery of said stream of said marking material and a plurality of second conduits for delivery of said impinging stream of said control fluid, wherein said module comprises:

a wedge shaped body having an upper planar surface, a lower planar surface, a front surface and a back surface; a trough having a means for removing possible contaminants in said marking material;

a plurality of first grooves longitudinally spaced along said upper planar surface of said body each with one end in communication with said trough and one end forming a marking material orifice; another plurality of second grooves longitudinally spaced along said lower planar surface of said body; and at least one marking material supply conduit extending from said back surface of said body into said trough;

an upper cover plate adapted for attachment to said upper planar surface of said body such that the lower surface of said upper cover plate encloses said first grooves forming said first conduits;

a lower cover plate having a plurality of control fluid supply channels each extending from the back surface of said lower cover plate and ending in an opening on the upper surface of said lower cover plate; said lower cover plate being adapted for attachment to said lower planar surface of said body such that said upper surface of said lower cover plate encloses said second grooves to form said second conduits and such that said openings on said upper surface of said lower cover plate are aligned with said second grooves; and

a means for nonaspiratively positioning said marking material orifice outside said stream of pressurized control fluid.

18. The apparatus of claim 17 further comprising:

a first pressurized source for delivering said marking material into said trough such that said marking flows out of said trough, through said first conduits and out of said module body through said marking material orifices; and

a second pressurized source for delivering said control fluid into said control fluid supply channel such that said control fluid flows continuously out of said control fluid supply channel, through said second conduits, and out of said module body through said control fluid orifices.

19. The apparatus of claim **13** or **18** further comprising control means for regulating flow of air from said second pressurized source to said control fluid supply channels in accordance with dye pattern information.

20. An apparatus for spraying a liquid marking material onto the surface of a substrate by nonaspiratively dividing a stream of said marking material into droplets by an impinging stream of pressurized control fluid directed at said surface, said apparatus comprising:

a rigid module body having a plurality of first grooves, a plurality of passages, and a trough for having a means for removing possible contaminants in said marking material;

an upper cover plate abutting said module body such that a surface of said upper plate encloses said first grooves so as to form a plurality of first conduits for delivery of said marking material, said first conduits having one end in communication with said trough and another end extending to the outside of said module body and forming a marking material orifice;

said plurality of passages formed completely by internal surfaces of said block for delivery of said impinging stream of said control fluid, said second passages having one end extending to the outside of said module body and forming a control fluid orifice; and

a means for nonaspiratively positioning said marking material orifice outside said stream of pressurized control fluid.

21. The apparatus of claim **20** further comprising:

a first pressurized source for delivering said marking material into said trough such that said marking material flows out of said trough, through said first conduits and out of said module body through said marking material orifices; and

a second pressurized source for delivering said control fluid into said passages such that said control fluid flows out of said passages and out of said module body through said control fluid orifices.

22. An apparatus for spraying a liquid marking material onto the surface of a substrate by nonaspiratively dividing a stream of said marking material into droplets by an impinging stream of pressurize control fluid directed at said surface, said apparatus comprising:

a module forming a plurality of first conduits for delivery of said stream of said marking material and a plurality of second conduits for delivery of said impinging stream of said control fluid, wherein said module comprises:

a wedge shaped body having an upper planar surface, a front surface and a back surface; a trough having a means for removing possible contaminants in said marking material; a plurality of first grooves longitudinally spaced along said upper planar surface of said body each with one end in communication with said trough and one end forming a marking material orifice; a plurality of passages longitudinally spaced in said body; and at least one marking material supply conduit extending from said back surface of said back into said trough;

an upper cover plate adapted for attachment to said upper planar surface of said body such that the lower surface of said upper cover plate encloses said first grooves forming said first conduits;

said passages including a fluid supply channel and a fluid delivery channel, said fluid supply channel being in fluid communication with said delivery channel and having a longer effective length than said delivery channel, and said delivery channels being aligned with said grooves; and

a means for nonaspiratively positioning said marking material orifice outside said stream of pressurized control fluid.

23. The apparatus of claim **22** further comprising:

a first pressurized source for continuously delivering said marking material into said trough such that said marking material flows out of said trough, through said first conduits and out of said module body through said marking material orifices; and

a second pressurized source for delivering said control fluid into said control fluid supply channel such that said control fluid flows out of said control fluid supply channel, through said delivery channel, and out of said module body through said control fluid orifices.

24. The apparatus of claim **21** or **23** further comprising control means for regulating flow of air from said second pressurized source to said control fluid supply channels in accordance with dye pattern information.

25. An apparatus for spraying liquid marking material onto the surface of a substrate nonaspiratively utilizing a source of pressurized control fluid and source of liquid marking material, said apparatus comprising:

(a) a block of rigid material having a plurality of first conduits for delivery of said marking material and a plurality of second conduits for delivering of said pressurized control fluids, and a plurality of third conduits for delivery of unused marking material away from said modules for removal of possible contaminants in said marking material;

(b) each of said first and third conduits having an inlet and an outlet for said liquid marking material;

(c) each of said second conduits having an inlet and an outlet for said pressurized control fluids;

(d) said inlet of said first conduits arranged for connection to said source of marking material;

(e) said inlet of each second conduits arranged for connection to said source of control fluids;

(f) said inlet of said third conduit arranged to communicate with marking material that has not passed through said outlets of said conduits;

(g) said outlets of said second conduits arranged adjacent to corresponding outlets of said first conduits and cooperating to effect division of a stream of marking material exiting said outlets of said first conduits into droplets by an impinging stream of said pressurized control fluid exiting said outlets of said second conduits; and

(h) a means for nonaspiratively positioning said outlets of said first conduits outside said stream of pressurized control fluid.

26. The apparatus according to claim **25** wherein said module comprises a trough, said first conduits having one end in communication with said trough and another end extending to the outside of said module body and forming a marking material orifice, said third conduits having one end in communication with said trough displaced from said first conduits and another end ex-

tending outside of said module body for delivering unused marking material away from said module.

27. The apparatus according to claim **26** wherein said trough defines a bottom and said inlets of said third conduits being in communication with said trough through said bottom and said outlet extending to the outside of said module for delivering unused marking material away from said module.

28. The apparatus according to claim **26** wherein said trough includes a rear wall; said third conduits include inlets in communication with said trough through said rear wall and outlets extending to the outside of said module body for delivering unused marking material away from said module.

29. The apparatus according to claim **26, 27** or **28** further comprising means for directing marking material under pressure to said first conduits.

30. The apparatus according to claim **29** further comprising means for recirculating marking material that has not passed through said first outlets or said marking material, that has not been sprayed onto fabric to said means for directing marking material under pressure.

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